mens are the skeletons of *Hyracotherium* and *Phenacodus* from the Wasatch and of *Hyrachyus* from the Bridger. There are also skeletons of Galecynus and Trispondylus, and material for the restoration of several other animals. Professor Cope has reserved the right of describing the new material, but the entire collection will be arranged and placed on exhibition as rapidly as possible, and will be permanently known as the Cope Collection. A large new storeroom on the upper floor of the new wing of the Museum has been set apart especially for it. All the specimens will be numbered; the types designated under the direction of Professor Cope, and all information regarding localities, dates, description, etc., will be entered on a special card catalogue. The collection will thus be made readily accessible to students.

The Exhibition Hall on the third floor of the new wing of the American Museum has been designed and cased for the entire collection of fossil mammals, and will be opened for exhibition in November. The line of large cases on either side of the centre of the hall is designed for complete mounts of *Aceratherium*, *Metamynodon*, *Palæosyops* and *Titanotherium* and other animals now in preparation. The smaller side cases will contain morphological exhibits of the evolution of members of the families; also cases arranged geologically to represent the faunæ of each horizon; and a series of upright A cases designed for the exhibits of the evolution of the teeth, feet, skull and other special parts of the skeleton.

The expedition of 1895, the fourth which has been sent out, entered the Uinta beds early in the spring and explored the three levels in which the Uinta deposits are divided, as late as the water supply admitted. The party was then reinforced by a photographer, and, under the direction of Dr. Wortman, moved north to the southern exposure of the Washakie basin, east of the Green River, and is now working in the *Uintatherium cornutum* beds with considerable success. The work of these expeditions is not confined to the collections of fossil mammals, but to the careful survey of the successive depositions in these various basins. Every basin visited is explored with the greatest care to determine the vertical succession and horizontal distribution of species. The main result of this exploration is to prove that each of the larger subdivisions of Leidy, Cope and Marsh is capable of being divided into a number of successive stratifications or beds, distinguished by characteristic species. The application of this method was begun by the Princeton expedition of 1880 in the surveys of Professor McMaster, but unfortunately was not followed up with sufficient care. Several years ago Mr. J. B. Hatcher showed that the lower portion of the White River beds was capable of subdivision into three clearly defined levels, and the American Museum party of 1893–94 proved that above the Titanotherium beds five other specific levels could be determined, thus dividing the White River beds into eight levels. In 1894 the Uinta beds were proved to be distinctly divided into three levels, the older of which overlaps the somewhat older Washakie beds, and the uppermost overlaps the beds of the more recent White River beds, thus demonstrating that the Uinta is the complete link between the Middle Eocene and the Lower Miocene or Oligocene. This summer the party is endeavoring to determine the exact relations of the Washakie depositions to the somewhat older Bridger deposition west of the Green River.

HENRY F. OSBORN.

THE GEOGRAPHICAL DISTRIBUTION OF THE MOLLUSCA.

WE hear a great deal of late concerning the habits, range of variation, and special characteristics of a great number of forms

of life; but very little is written concerning the methods by which species peculiar to one locality may be transported to others many miles distant. This is a subject which bears more closely on the origin of species than any other, and one which will yield some of the best results, if studied carefully and faithfully, and if original observations are made in the field. It is my purpose in this communication to briefly consider some of these transporting agencies as illustrated by the Mollusca, from facts gathered by myself while collecting in the field, and from reliable correspondence.

Distribution by the aid of birds.—Several years ago, while on a collecting trip to Florida, I took occasion to dissect several hundred migrant and resident birds and to carefully note the contents of their crops. In a large number of the crops I found the shells of mollusks which had been taken as food; these shells were mostly minute, and of the genera *Pupa*, *Amnicola*, *Pisidium* and *Vertigo*. These shells, being indigestible, and not affected by the gastric juices of the stomach, would naturally pass off with the fæces. In this manner, the shells of many species of mollusks, which were once supposed to inhabit restricted localities, have been found at a great distance from their recorded habitats. Especially would this be true during the migratory season, when a bird would swallow a species in one State and drop the shell with the fæces in another. The shells, of course, would in most cases be dead when dropped, the animal portion being used as food; but there are exceptions to this, for I have several authentic accounts of living mollusks being found in the stomachs of birds. As an example of the wide distribution of these small mollusks, I cite *Pupa armifera*, Say, which is found from Dakota and Kansas to the Eastern States and Mexico.

The Catbird (*Galeoscoptes carolinensis*) I found to feed only (so far as the Mollusca were concerned) on the minute land snails *Pupa* and *Vertigo*. It was frequently observed on the palmetto trees searching for these minute animals. The hawks and kites of Florida, especially the Everglade Kite, seemed to consider the animal of *Ampullaria depressa*, Say, a great delicacy, for in almost every crop dissected I found the remains of this mollusk. Heaps of the dead shells of this animal were always found beneath their roosting places. Frequently a hawk or kite will capture this fresh-water snail and carry it several miles to its roosting place; but many times another bird will overtake the one carrying the booty, and a dispute of ownership will follow, which nearly always results in the loss of the prey, which drops unharmed, perchance, into a pond which this species has not before inhabited, and there, if laden with eggs, as is frequently the case, establishes a new colony of *Ampullaria*. By this means, as well as others, this species has been distributed over a great portion of Florida. It is my belief that many a colony of mollusks, as well as other animals, has been formed in this manner.

Ducks, geese, swans and many other kinds of wild fowl, are very fond of snails, and I have never failed to find the remains of them in their crops. By means of these birds the shells of many mollusks have been transported for many miles, and have offered, doubtless, material over which some conchologist has worried and finally described them as a new species! I know of several instances where the eggs of a mullusk were found attached to the foot of a mallard, and several birds have come under my notice, which, when shot, had young Anodons and Sphæriums adhering to their toes. Many other instances might be cited of this character, but enough has been said to show that birds exert a wide influence in the distribution of the mollusca.

Distribution by the aid of fishes.—Various

species of fish feed upon snails as a regular diet. After feeding in one spot they repair in schools to some particular spot, often many miles distant from the feeding ground, where they digest the animal and eject the shell, either through the mouth or with the fæces. In this manner litoral mollusks are carried to the abyssal regions, and, I believe, have been described as deep-sea forms. The greater portion of the foregoing accounts relate only to the dead shells which have been ejected from the stomach of some vertebrate animal, and the change cannot be said to be a correct variation in habitat, save in the few cases cited where the living animal was transported; it is simply the dispersal of a skeleton from one point to another.

Dispersal of the living animal by means of insects.—It would hardly be supposed that insects could in any way be the means of distributing mollusks, and yet I have numerous records of such distribution. Some time ago a water beetle was captured, which had a *Sphærium* attached to one of its legs; another species was captured with an *Ancylus* attached to its wingcase. I have records of other instances where the larger water beetles had specimens of *Physa*, *Planorbis*, and even *Limnæa* attached to different portions of them. In this manner living mollusks have been transported from one pond to another, and so many of the fresh-water species have been distributed by the humble means of a water beetle.

Distribution by means of storms, ocean currents, etc.—We may now consider a change of habitat which affects the living animal more closely than in the cases previously cited. Many portions of Florida bordering the rivers and creeks are continually falling away and being carried into the Gulf, and so to Cuba, Yucatan and other parts of the West Indies and Mexico. These transported masses consist of three trunks, entwined vines, branches and roots of trees covered with earth and vegetation. Many times, during storms, whole tracts of land are washed away and portions of them of considerable size are carried many miles by the currents. Upon all of these natural rafts, mollusks are found which are transported to habitats a great many miles from those in which they first appeared. In this manner *Helices*, *Bulimi*, *Pupæ*, *Limnæa*, *Physa*, *Planorbis*, and a host of species too numerous to mention, are carried from the Southern States to Cuba, Mexico and Yucatan. No doubt many of the species of land and fresh-water shells found in Cuba which are also found in the Southern States, especially Florida, were carried there in this manner, or were carried from Cuba to the States.

In the Western States fresh-water and land shells are continually being carried from one point to another. In the early spring, when freshets and floods occur, the young fry, as well as the adult animals, are carried from the headwaters of the Mississippi River to various places along its banks upon driftwood, tree trunks and an innumerable number of natural rafts of this character. In this manner the species of Unio have reached a comparatively wide distribution. So also in our Great Lakes the fry of mollusks are carried from Huron to Ontario. Mountain streams, during freshets, are potent vehicles of transportation in the spring, and no doubt many mollusks living at high altitudes are carried by this means from the mountains to the valleys and plains below. As an example of this I cite the following case, furnished by a reliable correspondent: About two years ago a colony of *Vitrina limpida* was found in a Pennsylvania town just after a severe flood; the species had not been before observed, although the collector had searched the locality for several years preceding. These shells had undoubtedly been brought down the Alleghany River on rafts during the flood, and the little colony

had been formed. From last accounts the little colony was doing well. This is but one example of many which prove that mollusks are distributed in this manner. I have one authentic case of a number of Anodons being carried away by a whirlwind and falling several miles distant during a severe rainstorm.

Distribution by human agencies. Man has been a great factor in the distribution of all animal and vegetal life, and the Mollusca are no exception to the rule. The great Erie Canal has been a powerful transporting agent. In it we find species of *Physa*, *Limnæa* and *Planorbis*, which were once supposed to inhabit only the western lakes and rivers. Even European species, like the giant *Limnæa stagnalis*, have been brought over from Germany and France, and are now found from Illinois to New York; so also with several small Valvatas and Amnicolas. Land mollusks have also been brought from Europe, either adult or in the egg, and we now have several colonies of *Helix nemoralis* and *H. hortensis* in several parts of the United States. In the City of Mexico, in a little corner of the cypress grove at Chapultepec, is a large colony of *Helix aspersa*, which, up to the time of its discovery, in 1890, was not supposed to be found in Central America. It is now spreading over the valley of Anahuac, and will before long be a recognized part of the fauna of Mexico. This species was undoubtedly brought to Mexico with German goods, found a locality favorable to its existance, and has grown and multiplied. This same species is now found in Charleston, South Carolina; New Orleans, Louisiana; Portland, Maine; Nova Scotia; Santa Barbara, California; Hayti; Chili; etc. It is a curious fact that *Helix hortensis* was not accidentally introduced into the country, as were *H. nemoralis* and *H. aspersa*, but was first brought to Burlington, New Jersey, by Mr. W. G. Binney. This species does not thrive so well, nor does it spread so rapidly, as did the other species mentioned.

Our large garden-slugs, *Limax maximus* and *L. agrestis*, were introduced into this country some fifty years ago, and are now found all over the northeastern part of the United States and parts of Canada. The transportation of hothouse plants has been the principal means of distributing these species, for they are found more abundantly in greenhouses than in any other locality. Geological changes also tend to disperse mollusks and also to change their mode of living. A single example will suffice to illustrate this point. In Africa there is a lake (Lake Tanganyika) in which live a number of mollusks almost identical in the form of the shell and animal with the marine group of shells known as Trochids; yet these mollusks live in fresh water and have the principal characteristics of fresh-water species. Now this lake must at some time have been connected with the sea, and the change from salt to fresh water must have been very gradual in order not to have killed off all the animals. Numbers must have died during the change, and those that were the most enduring lived and multiplied. The result of the change is some of the most curious mollusks known to science. (*Limnotrochus*, *Tiphobia*, *Neuthauma*, *Tanganyicia*, *etc.*)

And thus I might go on and give hundreds of examples of the distribution of mollusks by natural and artificial methods; but I believe I have given enough to illustrate my point, which is that there is nothing so very wonderful in the finding of species hundreds of miles from their supposed natural habitat, and that the apparent 'paradox' of their discovery can be accounted for by some one of the examples given above. More attention should be given to the careful recording of facts such as those I have given, which are to my

mind far more valuable to science than the indiscriminate description of new species and genera, and a multitude of such facts would aid very materially in the solution of the origin of species, and the reasons for the gradual change from one type to another.

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CURRENT PROBLEMS IN PLANT MORPHOLOGY (I.)

THE QUESTION OF PTERIDOPHYTE PHYLOGENY.

IF the question be asked: which among living genera of Pteridophytes most closely resembles the hypothetical archetype, three answers are at hand. Goebel, of Munich, adheres to the Prantlian theory that *Hymenophyllum* of the leptosporangiate ferns may be regarded as primitive. The peculiar strength of this position lies in the apparent homologies between the filamentous prothallia of this fern and moss-protonema such as that in particular of *Buxbaumia*. Bower, of Glasgow, has brought forward for consideration the curious club moss *Phylloglossum* and constructs, under his strobilar hypothesis, a phylogeny passing from Lycopodiaceæ through the eusporangiate ferns to the leptosporangiate, practically an inversion of the older view. Campbell, of Leland Stanford, has argued ably the claims of the eusporangiate fern *Ophioglossum*, deriving from its region the Marattiaceæ, Isoetaceæ, Lycopodiaceæ and leptosporangiate series of ferns.

The three views may really be reduced to two; Goebel maintains a leptosporangiate origin for the group; Bower and Campbell would establish an eusporangiate origin. Therefore one view is quite exactly the converse of the other. The peculiar strength of the new position lies in the remarkable sporophytic homologies which have been indicated between *Anthoceros* of the Hepaticæ and *Marattia* and *Lycopodium*.

At present the German school labors under a certain disadvantage, although the position of Dr. K. Goebel is in accord with the new ideas of mechanomorphosis developed in the rough long ago by Sachs and De Bary and lately carried forward by Sachs, and among zoölogists by Roux, Driesch and many others. The disadvantage consists in a necessary opposition to the well-established hypotheses of differentiation, an opposition in which an actual metamorphosis of embryonic rudiments (Anlagen) is maintained. Bower's theory of sterilization, than which nothing could seem more reasonable under the generally accepted interpretations of ontogenetic and paleontologic records, must be set aside, and, finally, little use can be made of the remarkable pteridophytic characters of the *Anthoceros* and *Notothylas* sporophytes; but one must turn away from this group and bring forward the more specialized mosses as archetypal plants.

Hugo Glück, in Flora 80: 303–387, 1895, under the title *Die Sporophyll Metamorphose*, gives a valuable census of anatomical resemblances between sporophylls and foliage leaves, and after an examination of sporangial protective apparatus, viz., hairs, pits, indusia, rolled-over margins, etc., of sporophyll petioles, and of various transitional forms, proposes as established the thesis that 'all sporophylls are metamorphosed foliage leaves.' This is almost exactly the converse of the Bower-Campbell position which maintains the derivation of non-sporangium-bearing leaves from a sporangial tract. The argument of Glück is by no means convincing, for his evidence, apparently, might be used with quite as much force on the other side.

Goebel, carrying the war into Africa, brings out a paper entitled '*On Metamorphosis in Plants*' in Science Progress 3: 114–126, 1895, which expresses his views tersely and clearly. The outcome of the debate is interesting, for it promises to resolve itself